

1-1-2000

Effects of chromium picolinate and a moderate exercise program on body weight, body composition, muscle strength, and muscle girth

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Effects of chromium picolinate and a moderate exercise program on body weight, body
composition, muscle strength, and muscle girth

by

Carla May Dornsbach

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

Major: Exercise and Sport Science

Major Professor: Douglas S. King

Iowa State University

Ames, Iowa

2000

Graduate College
Iowa State University

This is to certify that the Master's thesis of
Carla May Dornsbach
has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy

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CHAPTER I:

INTRODUCTION

Chromium is a trace metal required for normal carbohydrate and lipid metabolism and glucose homeostasis (55, 72). By increasing the activity of insulin while requiring less insulin for heightened activity (37), chromium has been shown to potentiate the action of insulin (14, 59, 71). Although no recommended daily allowance has been established, the National Research Council recommends an estimated safe and adequate daily dietary intake of trivalent chromium of between 50 to 200 μg (58). However, approximately 90 percent of the U.S. population may be consuming less than the recommended minimum daily intake of 50 μg (6, 9, 41). Furthermore, a large segment of the U.S. population may be at risk of at least a marginal deficiency in trivalent chromium (56, 64) due to the high consumption of refined, processed, and preserved foods that have lower chromium content than their raw food sources (64). Dietary chromium can be obtained through consumption of organ meats, cheese, wheat germ, Brewer's yeast, wine, and beer (29, 58).

Signs of marginal chromium deficiency include impaired glucose tolerance, elevated concentrations of fasting insulin, elevated circulating insulin, decreased insulin binding, decreased insulin receptor number, glucosuria, elevated cholesterol and triglycerides, decreased HDL cholesterol, and hypoglycemic symptoms (3, 9, 14, 71). Additionally, specific stresses shown to enhance chromium losses are pregnancy and lactation (10, 27), high sugar diets (4, 41), physical trauma (14), and strenuous exercise (3, 41). The latter is noted as a characteristic of athletes and other highly active individuals. Although dietary sources of chromium can be found in foods, (58), the risk of deficiency in certain populations may suggest a need for chromium supplementation. Furthermore, an established therapeutic:

toxic dose ratio of 1:10,000 μg (58) makes trivalent chromium among the safest nutritional elements. Signs of toxicity have not been observed even after prolonged application of GTF supplementation (35). In early studies chromium is referred to as Glucose Tolerance Factor.

Trivalent chromium is the most bioavailable form of chromium. Furthermore, chromium III absorption may be increased several fold when combined with picolinic acid. Thus, chromium picolinate is a compound of one trivalent chromium atom surrounded by three molecules of picolinic acid (16). Trivalent chromium and chromium picolinate supplementation have been shown to improve glucose and lipid metabolism and protein anabolism (2, 4, 8, 9, 34, 37, 39, 40, 44, 55,69) in animals, healthy persons, and non-healthy people. Consequently, both trivalent chromium and chromium picolinate have been promoted as a dietary supplement claiming to enhance weight loss and athletic performance by decreasing body fat and enhancing gains in lean body mass (24, 40). However, previous studies investigating the relationship between exercise and chromium picolinate intake have demonstrated conflicting results (18, 24, 31, 33).

Chromium picolinate supplementation (200 $\mu\text{g}/\text{day}$) with weight training was shown to enhance gains in lean body mass with decreases in body fat beyond that achieved with training alone in collegiate football players (24). Conversely, other research suggests that chromium picolinate supplementation (200 $\mu\text{g}/\text{day}$) does not facilitate changes in body composition or strength during a program of intense weight lifting in male football players (18). However, when taken during a moderate strength training program, chromium picolinate supplementation (200 $\mu\text{g}/\text{day}$) was shown to increase body weight in female subjects with no change in lean body mass or body fat percentage (33). Thus, because lean tissue is known to weigh more than fatty tissue and no increases in body fat were observed,

these findings indicate an increase in lean body mass beyond that achieved from training alone when subjects were supplemented with 200 μg of chromium picolinate daily (33). More recently, Hallmark et al. (31) concluded that chromium supplementation when taken in combination with a progressive resistive training program, did not promote a significant increase in strength and lean body mass nor a significant decrease in percent body fat (31).

These conflicting findings may be due to the variances in control of diet, cardiovascular activity, and resistance training protocols. Although numerous studies have demonstrated a relationship between glucose homeostasis and lipid metabolism and trivalent chromium or chromium picolinate supplementation (2, 4, 8, 9, 34, 37, 39, 40, 44, 55,69), few studies have actually demonstrated the relationship between the metabolic function of chromium picolinate and improved fat loss and gains in lean body mass. Furthermore, no published studies have investigated the effects of chromium picolinate supplementation in healthy female subjects participating in a moderate exercise program including both cardiovascular and resistance training. Nevertheless, nutritional supplements such as chromium picolinate, “Chroma Slim”, “Fat Burners”, “Cyber Slim”, and other weight loss enhancing and body building products that contain chromium picolinate are widely promoted to meet America’s fast paced lifestyle as a quick fix remedy to obesity. Additionally, many product labels encourage consumers to engage in a regular exercise program when taking their respective supplement despite the lack of confirmed findings. Consequently, the purpose of this study was to investigate the effects of chromium picolinate supplementation (200 $\mu\text{g}/\text{day}$) on changes in body composition, muscular strength, muscle girth, and body weight in young women with a moderate exercise program including both cardiovascular and resistance exercise. Based on previous research indicating that females may respond more

readily to chromium picolinate supplementation, it is the hypothesis of this study that young healthy females supplemented with 200 μg of chromium picolinate while participating in a combined resistance and cardiovascular exercise program will experience a decrease in body fat and increase in lean body mass beyond that achieved with training alone.

CHAPTER II:

LITERATURE REVIEW

Physiological role of chromium

Chromium has been identified as the active component of Glucose Tolerance Factor (GTF), a dietary ingredient required for optimal glucose metabolism (55, 72). Trivalent chromium is believed to act as a co-hormone of insulin by potentiating and amplifying its action (35, 38, 59, 71). Although its specific action on these cells is unknown (10), trivalent chromium has been suggested to form complexes with insulin and the mitochondria involving chromium and sulfur linkages at the mitochondrial membrane of tissues (15, 17). Chromium deficiency is associated with glucose intolerance and elevated mean blood chromium levels after a glucose load in humans (45). Chromium deficiency has also been acknowledged as a contributor to hyperglycemia (45). Rats deficient in chromium have been found to display disturbed glucose metabolism simulating that of Non Insulin Dependent Diabetes Mellitus (NIDDM) (63). Low chromium intake has also been shown to lead to detrimental effects on glucose tolerance, insulin, and glucagon in humans with mildly impaired glucose tolerance (9). The most extensively studied chromium deficient tissue in vitro has been the rat epididymal fat pad in which chromium increased the rate of glucose uptake, oxidation of glucose, and incorporation of glucose carbon into fat in the presence of insulin (49). Similar increases in glucose uptake have been observed with dietary chromium supplementation in rats (49, 55). Additionally, chromium supplementation may restore impaired functions to near normal within two hours of supplementation (49).

Additionally, GTF prepared from Brewer's yeast produced a 36% reduction in plasma glucose in mice without disturbing liver glucose production (55, 68). Glucose tolerance,

insulin, and glucagon secretion have also all been shown to improve during chromium supplementation in humans (9). However, higher or lower doses than those used (200 µg/day) were less effective (68). Thus, it appears that repletion of chromium improves hyperglycemia to a certain degree but more than normal amounts of insulin are still required to regulate the elevated glucose (45). However, each of these studies supplemented subjects with the same dose amount of chromium regardless of differences in sex, body weight, or lean body mass. Although blood chromium increased with a glucose load (45) reinforcing the relationship between glucose homeostasis and chromium status, perhaps the relationship between chromium dose to sex and lean body mass should be considered.

Chromium supplementation has also been suggested to have beneficial effects on lipid metabolism, cholesterol levels, and certain lipoproteins (1, 20). Rabbits fed a thermogenic diet with daily chromium injections were observed to have reduced total cholesterol content of the aorta and reduced areas of the aortic intima covered by plaques (1). Furthermore, chromium may influence cholesterol synthesis in rats by allowing phospholipid oxidation and increasing cholesterol synthesis (1). Thus, it has been suggested that chromium deficiency may be associated with a variety of parameters involved in the risk of atherosclerosis, including diabetes (1). It has also been suggested that chromium supplementation may prove to have health benefits beyond those associated with a healthy percentage of body fat and a healthy weight.

In addition to the role of chromium in glucose and lipid metabolism, chromium deficiency has been associated with alterations in nitrogen anabolism. Chromium deficiency has been shown to cause weight loss unless energy intake was increased by 55% due to its effects on protein anabolism and growth (39). Rats deficient in chromium were also shown

to have diminished growth rates, which returned to normal with chromium supplementation (52) indicating the role of chromium in muscle growth. Furthermore, rats with sufficient chromium stores had improved growth and survival (63) while both male and female supplemented rats have been shown to weigh more than chromium deficient rats (63). Chromium has also been shown to be retained by bone and has been associated with skeletal growth (63). Immature bone has been shown to retain 12% of a chromium dose 24 hours after injection while mature bone retained only 5% (63). Despite improved glycogen and protein synthesis in response to insulin with chromium intake, it is important to note that the improved effectiveness of insulin and increased growth in chromium supplemented rats cannot be attributed to chromium alone because of the many other hormones and factors involved in growth (64). Furthermore, while chromium deficiency appears to slow growth, it has been noted that the effect of chromium deficiency on impaired growth is not perceived as impressive when compared with the cessation of growth observed in deficiencies of other trace elements (63).

Chromium appears to be effective in very small amounts as only two to three percent of an oral chromium dose is absorbed in a rat model (49). Of the few percent of dietary chromium absorbed in the rat, more than half is excreted within the following day. Furthermore, while chromium infusion was shown to improve protein anabolism, lipid related abnormalities, and decrease glucose levels to normal with three days of application (39), excess chromium was excreted in the urine. Consequently, chromium stores appear to become saturated (39) and intake beyond saturation is not used. Thus, individuals with sufficient chromium stores possibly would not benefit from supplementation. Furthermore, ingesting supplements beyond the recommended safe and adequate amounts as suggested by

several products may not be beneficial. Products commonly recommend daily supplementation of 200 µg for women and 400 µg for men.

Mechanisms of chromium action

Trivalent chromium is believed to act as a co-hormone of insulin by potentiating and amplifying its action (35, 38, 59, 71). Although the mode of interaction between insulin and chromium is not known, it has been demonstrated that insulin must be present for chromium action and chromium must be present for insulin action (49). Chromium appears to act directly on the β -cells of the pancreas (10). Although its specific action on these cells is unknown (10), trivalent chromium has been suggested to form complexes with insulin and the mitochondria involving chromium and sulfur linkages at the mitochondrial membrane of tissues (15, 17), thereby enhancing the functional action of insulin at the tissue as compared to increasing the production of insulin. Furthermore, trivalent chromium has been suggested to bind specifically to siderophilin (transferrin), plasma proteins in the blood, where it competes with iron for a binding site (36, 50). The presence of transferrin and albumin, plasma proteins, are thought to be needed in at least subphysiologic levels for maximal absorption of trivalent chromium (22). Furthermore, absorption of supplemental chromium through the gastrointestinal wall does not appear to be a prerequisite of binding the element to the beta globulin fraction of the blood (36).

Factors affecting chromium transport and absorption

Although previous diet has been shown to have no effect on chromium absorption (44, 47), nicotinic acid and iron status do appear to affect the responsiveness of individuals to chromium supplementation. Iron has been suggested to depress chromium binding and people with hemochromatosis retain less chromium than people with normal iron stores (63).

Furthermore, less chromium was found to bind to siderophilin (transferrin) as more iron was added to the blood stream (63). Picolinic acid and Vitamin B₆ have also been suggested to affect iron metabolism in cells by overcoming the competition between dietary iron, zinc, and possibly chromium (23, 25). Picolinic acid is formed in the body from tryptophan metabolites via the action of three separate enzymes (25). Tryptophan is one of the ten essential amino acids. At physiological pH, picolinic acid fully dissociates and forms stable complexes with essential metals such as chromium and zinc and improves the transport of essential metals by overcoming the competition between them and iron (25). Thus, because picolinic acid has also been found to affect iron metabolism in cells by withholding iron from cells (25), adding picolinic acid may allow selective withholding of iron from the transferrin binding site so chromium can bind in its place to induce growth by increasing energy use and facilitating protein anabolism (25, 26). This competitiveness may also explain why excess iron stores depress chromium binding and inhibit retention in that, perhaps, these proteins prefer iron to chromium. Consequently, it may be that adding picolinic acid to chromium alters the affinity of transferrin for iron to prefer chromium for growth enhancement (25, 26). Furthermore, Lukaski et al. found that transferrin saturation was decreased 24% more with chromium picolinate supplementation than with chromium chloride or placebo (46). It is interesting to note that many supplements used in body building encourage a high protein intake when high protein consumption alone or combined with elevated liver picolinic carboxylase in the diabetic rat has been suggested to influence zinc, copper, and other trace metal metabolism (40). Nevertheless, the improved insulin sensitivity with chromium intake and improved bioavailability of chromium from the addition of picolinic acid has resulted in the formation of chromium picolinate.

Chromium picolinate is a compound of one chromium atom surrounded by three molecules of picolinic acid (33). This compound is suspected to improve the efficiency of body fat utilization and the ability to develop and maintain muscle mass (24). Thus, it has been suggested that chromium picolinate decreases body weight and body fat while enhancing gains in lean tissue when combined with moderate exercise.

Chromium picolinate and exercise

The essentiality of chromium to normal metabolism has instigated interest in the metabolic effects involved in response to various types of exercise. Endurance exercise training has been shown to enhance chromium losses and increase muscle tissue chromium levels in rats (70). After progressively increasing running time and intensity up to a moderate exercise program, rats ran 60 minutes, six times per week for 12 weeks. Additionally, a single bout of running increased chromium excretion in humans (7, 13). Furthermore, Evans investigated the relationship of chromium picolinate and body composition in two separate studies. Ten male students participated in a university weight training class while maintaining their normal dietary and activity habits. Although training intensity was not specified, subjects trained twice per week for forty minutes each session performing both upper and lower body exercises (24). At the end of the 40 day training regime, Evans reported that male subjects consuming chromium picolinate increased body weight by 2.2 kg, 73% of which was reported to be due to increased lean body mass alone (24) compared to the placebo group whose body weight and percent body fat both increased significantly. When the gains and losses of lean body mass and body fat, respectively, were compared between groups, the increase in lean body mass of the chromium picolinate supplemented men was greater than the placebo group. Consequently, it was concluded that

chromium picolinate supplementation (200 µg/day) with weight training enhanced gains in lean body mass with decreased body fat beyond that achieved with training alone in male weight training students (24). Additionally, collegiate football players volunteered to participate in a weight training program four days per week, 60 minutes per session for 6 weeks (24). However, neither training intensity nor the exercises performed were specified. Evans reported that after 14 days, subjects consuming 200 µg of chromium picolinate lost 2.7% body fat and gained 1.8 kg of lean tissue (24). Furthermore, by the end of the six week training regime, subjects taking the supplements had lost 1.2 kg of body weight, gained 2.6 kg of lean body mass, and lost 3.6% body fat, which is a 23% decrease (24). Additionally, when the gains in lean body mass and loss of body fat were compared statistically between groups, the lean body mass of the chromium picolinate supplemented group was 44% greater than the placebo group, while the decrease in body fat was 3.5 times greater in the chromium supplemented men (24).

More recent findings have supported the finding that chromium excretion increases with exercise and chromium supplementation, but none have found significant changes in lean body mass, fat body mass, or strength in conjunction with a variety of exercise programs (18, 33, 43). An investigation by Clancy et al. suggests that chromium picolinate supplementation (200 µg/day) does not facilitate changes in body composition nor strength during a program of intense weight lifting in male football players (18). Subjects participated in spring training for nine weeks while ingesting either 200 µg of chromium picolinate or a placebo (18). However, the intensity of weight training was not specified (18).

In contrast, chromium picolinate supplementation (200 µg/day) of beginning weight training students who participated in a moderate strength training program resulted in increased body weight in only female subjects with no change in lean body mass or body fat percentage of chromium supplemented female subjects (33). Subjects exercised three days per week for 40 minutes over 12 weeks performing the bench press, squat, military press, bent over row, dumbbell flies, lat pull downs, arm curls, and tricep extensions (33). Subjects were instructed to choose a weight that would allow them to complete at least 6 repetitions and fatigue them by 10 repetitions (33). The amount of weight lifted was progressively increased as strength increased throughout the 12-week training program. The chromium picolinate supplemented female subjects gained significantly more weight, 2.5 kg as compared to 0.6-1.3 kg in the other three groups. The increased body weight within groups was also significant in that the group of females supplemented with chromium picolinate experienced a 4.3% increase in body weight as compared to a 0.9-2.0% increase in the other three groups. The males supplemented with chromium picolinate did not have a greater gain in muscle girth than those taking a placebo (33). However, chromium picolinate-supplemented females showed a 3.0 cm overall increase in muscle girth while females taking a placebo showed no measurable increases in muscle girth (33). Nonetheless, the mean increase in the sum of circumferences for all groups was 2.3 cm due to training alone ($p = 0.0001$). One may postulate that females taking chromium picolinate did experience a greater increase in lean body mass beyond that achieved with exercise alone as supported by the differences in body weight gains. However, the change in the sum of circumferences or skinfolds was not different between groups. These researchers concluded that chromium picolinate does not increase body fat loss beyond those due to exercise alone (33).

Hallmark, et al. also recently concluded that chromium supplementation in conjunction with a progressive resistive exercise training program does not promote a significant increase in strength and lean body mass nor a significant decrease in percent body fat (31). Subjects trained three times per week for 12 weeks. Two sets of 8-10 repetitions were performed at 90% of the 1RM with 60 seconds rest between sets (31). Once 10 repetitions could be performed, the weight was increased in five pound increments. All exercises were performed on Keiser variable resistance exercise machines and included the following nine exercises: leg press, leg extension, leg curl, chest press, lat pulldown, overhead press, seated row, tricep dumbbell extensions, and bicep curls (31). Although the resistance training protocol was highly controlled, no cardiovascular exercise was included.

Lukaski, et al. examined the effects of 3.3-3.5 μmol of chromium chloride or chromium picolinate or placebo (0.1 μmol chromium) and resistance training on body composition strength and trace element status of men (46). Subjects exercised 5 days per week for 8 weeks. Subjects initiated workouts with 8-12 repetitions at 50-65% of 1RM followed by four to 8 repetitions at 70-80% 1RM, and concluded with one repetition at 95-100% 1RM. Four exercises were performed including bench press, leg press, leg curls, and lateral pull downs. It was concluded that chromium supplementation has no effect on body composition or strength in male subjects. (46)

Summary and purpose of investigation

Healthy people with sufficient chromium storage show elevated plasma chromium levels after ingestion of glucose or injection of insulin (44). Furthermore, increased blood chromium levels in response to an oral glucose tolerance test have been accepted as an index of assessing chromium nutritional state when a person has sufficient chromium stores (32).

Dietary chromium intake can also be analyzed to identify chromium intake relative to chromium excretion. Additionally, when sufficient chromium stores exist, an oral glucose tolerance test (OGTT) increases urinary chromium excretion (32). Insulin mobilizes chromium so that losses are excreted in the urine (32). Thus, urinary chromium values are good indicators of recent chromium intake (10, 43, and 48). Although the effects of chromium on glucose, lipid, and nitrogen metabolism, insulin action, and chromium excretion have been demonstrated, the degree to which these metabolic actions affect anthropometric changes with an exercise program remains unclear. Specifically, no studies have investigated the claims made to a large segment of the target population, young females. Consequently, the purpose of this investigation was to evaluate the effects of chromium picolinate supplementation combined with a moderate exercise program, including both cardiovascular exercise and resistance training, on changes in body weight, body composition, muscle girth and muscle strength in healthy female subjects aged 18 to 24 years of age.

CHAPTER III:

METHODS

Subjects

Subjects were recruited through campus fliers and class announcements in the Department of Health and Human Performance. Twelve subjects were randomly selected from a group of female volunteers in the general population. Subjects were randomly assigned to placebo (PL; n=6) or a chromium supplemented (CR; n=6) group. Criteria for participation included no competitive status, females 18 to 24 years of age, persons who self-reported to not be taking or not have taken enhancing supplements in the previous three months, absence of anemia as determined by pretraining hematocrit and hemoglobin measurements, the absence of diabetes or CVD as determined by an oral glucose tolerance test and graded exercise test prior to training, respectively. Both groups participated in an eight week supervised cardiovascular and resistance training program. Subjects assigned to PL and Cr did not differ with respect to age, height or Body Mass Index (Table 1).

Table 1: Subject Characteristics

Group	PL	CR
Age (yrs)	21.2 ± 2.2	21.5 ± 1.9
Ht (cm)	168 ± 14.9	169 ± 5.2
BMI	23.3 ± 1.7	23.6 ± 5.8

Supplementation

CR ingested 200 µg of chromium picolinate daily in capsule form. The placebo group ingested an identical capsule containing 200 µg of sucrose as a placebo. Each individual was provided with a vial containing the exact number of either chromium capsules or placebo capsules at the onset of the exercise program. Each subject was encouraged to bring their vial with them to each exercise session so that the remaining capsules could be counted and ingestion monitored. Each subject was also reminded at each exercise session to take their capsules.

Training regimen

Cardiovascular and resistance training exercises were designed to increase the fitness level of women subjects women aged 18-24 years of age. Both PL and CR participated in resistance and cardiovascular activity for 8-weeks. An 8-week training regimen was selected based on recommendations that training adaptations occur within four to 20 weeks when subjects exercise 2-3x per week (28). Subjects performed a progressive resistance training and cardiovascular exercise program according to the schedule outlined in Table II.

Table II: Training Regimen

Resistance Training				Cardiovascular Training	
<u>Week</u>	<u>Frequency</u>	<u>Intensity</u>	<u>Sets/Repetitions</u>	<u>Time</u>	<u>Frequency</u>
I, II	MWF	65% 1RM	3 x 12 repetitions	30 min.	T, Th
III-VI	MWF	85% 1RM	3 x 8-10 repetitions	30 min.	T, Th
VII, VIII	MF	95% 1RM	5 x 3-5 repetitions	30 min.	T, Th

Each subject performed three sets of repetitions on three lower body, Keiser (Fresno, CA) variable resistance training machines. Exercises were selected to train the large muscle groups of the lower body. Subjects performed the leg press, leg curl, and knee extension exercises three times per week throughout the first 6 weeks followed by just two sessions per week the final two weeks. The amount of weight lifted was initiated at 65% of the initial 1RM for the first two weeks. During the subsequent four weeks, subjects lifted a resistance equal to 85% of the initial 1RM. Subjects lifted at 95% of their initial 1RM throughout the final two weeks. Thus, the number of repetitions decreased according to the amount of weight lifted from three sets of 10-12 repetitions to three sets of 8-10 repetitions to five sets of 3-5 repetitions or to failure. One repetition maximums were determined after two practice trials performed on two separate days, a minimum of two days prior to the actual testing. The 1-RM during practice trials was used to determine the starting weight during testing. All subjects performed a light, rhythmic cardiovascular warm up and stretching 5 minutes prior to testing. Subjects attempted one maximal exertion followed by 2-3 minutes of rest before attempting another maximal exertion at a resistance approximately 5% greater than the previous attempt. The 1-RM was obtained in 4 or fewer attempts for each subject. All testing and training was performed on Keiser variable resistance equipment including the Leg Press, Leg Curl, and Knee Extension. Training records were filed at the end of each workout and collected at the end of each week throughout the 8-week training program. The researchers and research assistants monitored all exercise sessions. Additionally, both groups participated in 30 minutes of cardiovascular exercise on a treadmill, Stairmaster, or cycle ergometer on the two days per week when they were not lifting weights. Subjects

exercised at 65% of their HR_{peak} the first two weeks, and 70% of their HR_{peak} throughout the final 6 weeks of the study. Peak heart rates achieved were measured using a Polar heart rate monitor during a maximal graded exercise test performed on each subject.

Intensity levels for both resistance training and cardiovascular exercise were selected based on recommendations of the American College of Sports Medicine (28). The American College of Sports Medicine suggests that exercise intensities of at least 60% of a 1RM should be sufficient to increase strength. Additionally, the most rapid strength gains are achieved when a muscle is exercised at 80-100% of maximum exertion. To continue improving muscle strength with resistance training, the workload must be progressively increased to continue overloading the muscle. Furthermore, ACSM recommends exercising at 70-85% of the heart rate achieved on symptom-limited treadmill test, for 20-60 minutes, 3-5 days per week. A lower cardiovascular intensity was chosen during the first two weeks of training so that all subjects could complete the 30 minutes in the early phase of conditioning. Additionally, 70% of peak heart was selected for the remaining six weeks to minimize the risk of injury and improve subject compliance. Heart rates were taken manually by the researchers and/or research assistants.

Analyses

Measurements were taken before and after the eight week training period. Three-day food intake records were recorded by each subject during the pre testing measurements so that subjects could duplicate their food intake during the days preceding the post testing to insure that the same food was eaten prior to each glucose tolerance test. Maximal oxygen uptake was measured using commercial software (TurboFit, Vacumed, Ventura, CA) and the Bruce Protocol Treadmill test to determine appropriate exercise intensities throughout the

training regime and to measure changes in cardiovascular capacity. Oxygen consumption, expired gases, heart rate, and RPE were collected throughout each test. All testing was performed in the Exercise Clinic at Iowa State University. One repetition maximum exertion was measured after three practice trials during the week prior to the initial training session and the week following the last training session. Testing was performed on the leg press, knee extension, and leg curl machines to determine training intensity and measure changes in muscular strength. One repetition maximum testing was also performed after each training intensity. Body composition using skinfold calipers at 9 sites, body weight, and muscle girths at 8 sites were measured before training, after each training intensity, and post training. Hydrostatic weights were measured pre and post testing. Body compositions were calculated using Jackson-Pollock equations (28). Hemoglobin and hematocrit were measured during pre-testing to insure the absence of anemia in subjects throughout the study.

Statistical analyses

A Two Way Repeated Measures Analysis of Variance (ANOVA) was performed to examine changes in all training and anthropometric variables. Data are reported as means \pm SEM. A level of significance was set a $P < 0.05$ for all statistical analyses. Neuman-Keuls multiple comparison tests were performed to determine the effect of each training intensity on individual variables. Two subjects did not participate in the final training stages nor post testing due to one having kidney stones and the other developing mononucleosis. Missing data were calculated using the formula and method of Ostle and Mensing (59).

CHAPTER IV:**RESULTS****Muscle strength**

Leg press strength was not different between the placebo supplemented group (PL) and the group supplemented with 200 μ g of Chromium Picolinate (CR) before or after training. Additionally, supplementation did not increase strength beyond that achieved from training alone. When data from PL and CR are combined, training increased leg press strength from $3,348 \text{ N} \pm 113$ to $3,789 \text{ N} \pm 113$ pre and post training (Figure 1; $p < 0.001$).

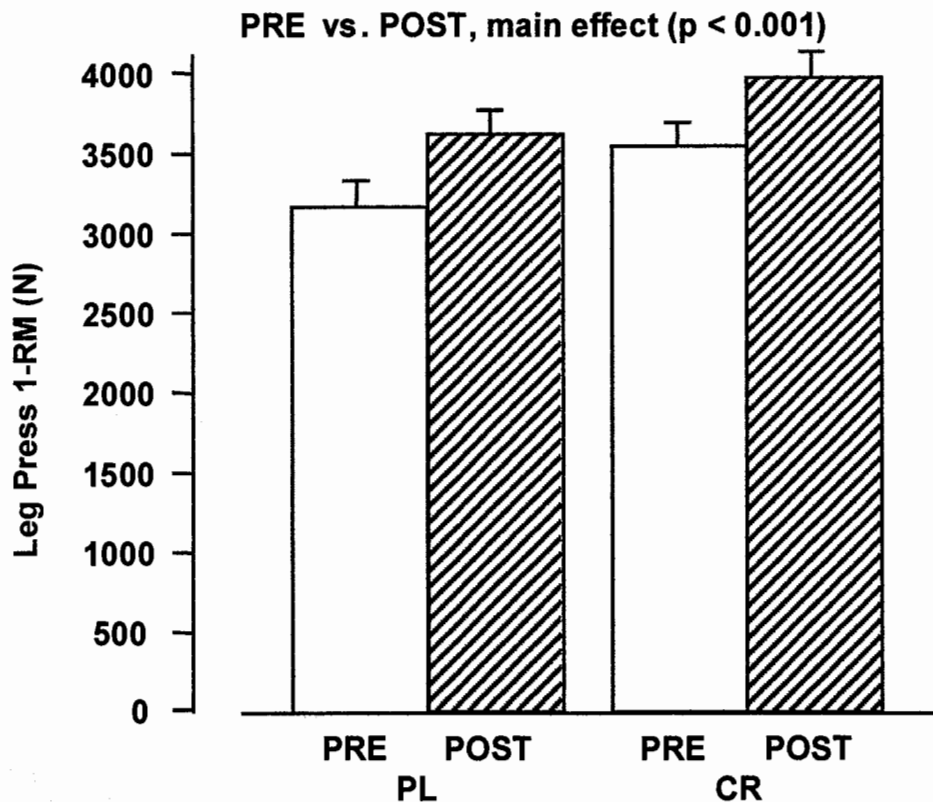


Figure 1. Leg Press 1-RM before and after a progressive, lower body, 8-week resistance training program combined with 200 μ g/day chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Leg Press 1RM was significantly greater after training in both CR and PL (significant main effect; $p < 0.001$).

Knee extension strength was not different in the PL and CR before or after training. When data from PL and CR are combined, training increased knee extension strength from $515 \text{ N} \pm 20$ to $621 \text{ N} \pm 20$, (Figure 2; $p < 0.001$).

Leg curl strength was not different in the PL and CR before or after training. When data from PL and CR are combined, leg curl strength increased from $528 \text{ N} \pm 22$ to 632 ± 22 , (Figure 3; $p < 0.001$)

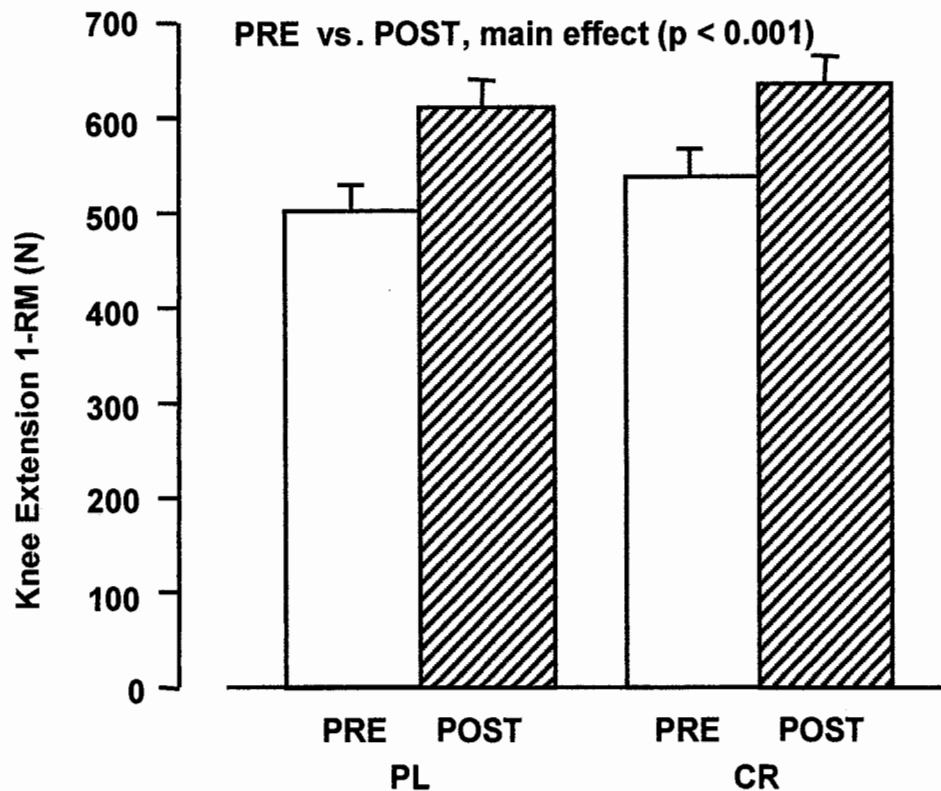


Figure 2. Knee Extension 1-RM before and after a progressive, lower body, 8-week resistance training program combined with $200 \mu\text{g/day}$ chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Knee Extension 1RM was significantly greater after training in both CR and PL (significant main effect; $p < 0.001$).

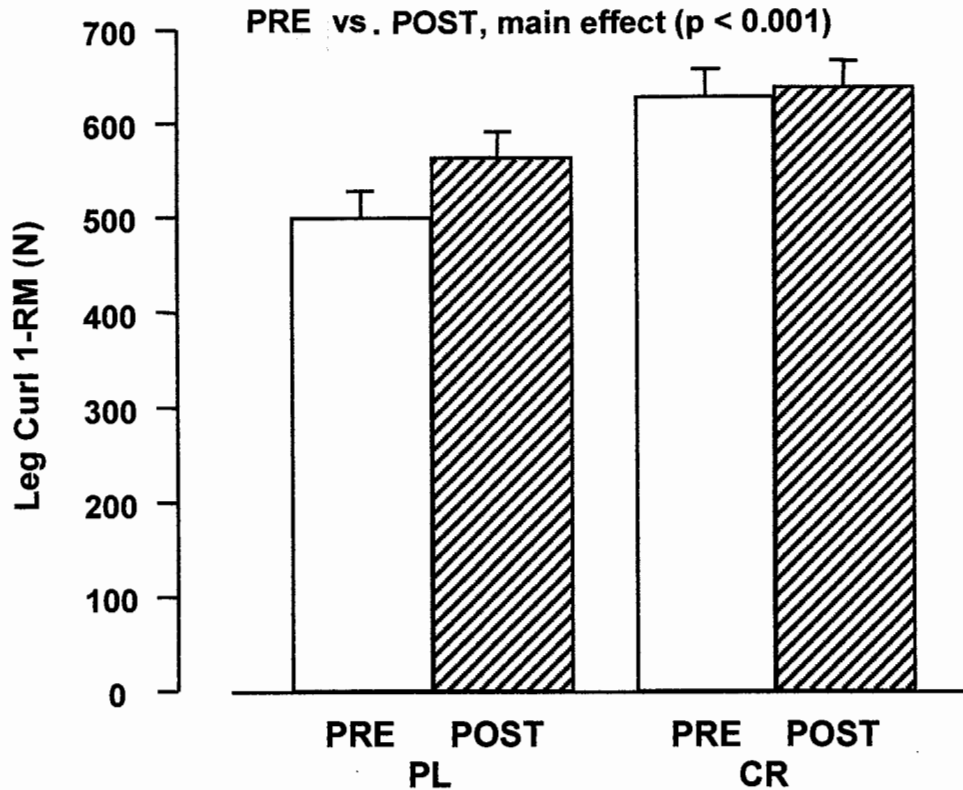


Figure 3. Leg curl 1-RM before and after a progressive, lower body, 8-week resistance training program combined with 200 μ g/day chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Leg Curl 1RM was significantly greater after training in both CR and PL (significant main effect; $p < 0.001$).

Cardiovascular adaptations to training

Peak oxygen consumption ($V_{O_{2peak}}$) was not different between PL and CR before or after training. Although supplementation did not enhance improvements in cardiovascular capacity, when data from PL and CR are combined, peak oxygen consumption increased from 41.0 ml/kg/min \pm 2.1 to 48.7 ml/kg/min \pm 2.1 due to training (Figure 3). Furthermore, oxygen consumption during stages I and II of the Bruce Protocol increased nearly twice as much in CR compared with PL after training. Oxygen consumption increased 5.5% more in CR during stage III and 6.3% in Stage IV than PL.

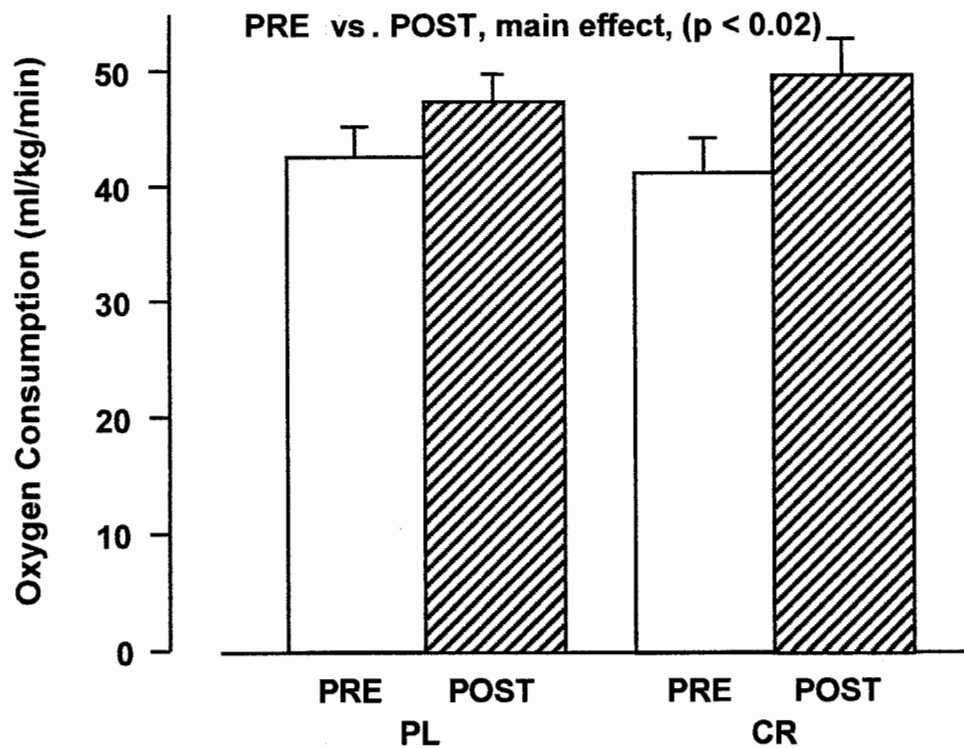


Figure 4. Peak oxygen consumption during a graded maximal treadmill test before and after an 8-week moderate cardiovascular program combined with 200 μ g/day chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Peak Oxygen consumption was significantly greater after training in both CR and PL (significant main effect; $p < 0.02$).

Peak heart rate achieved during a graded, symptom limited treadmill test was not different between PL and CR before training or after performing 8-weeks of cardiovascular exercise. When data from PL and CR are combined, peak heart rate achieved increased from $189 \text{ bpm} \pm 4$ to $193 \text{ bpm} \pm 4$, (Figure 5; $p = 0.003$) with training.

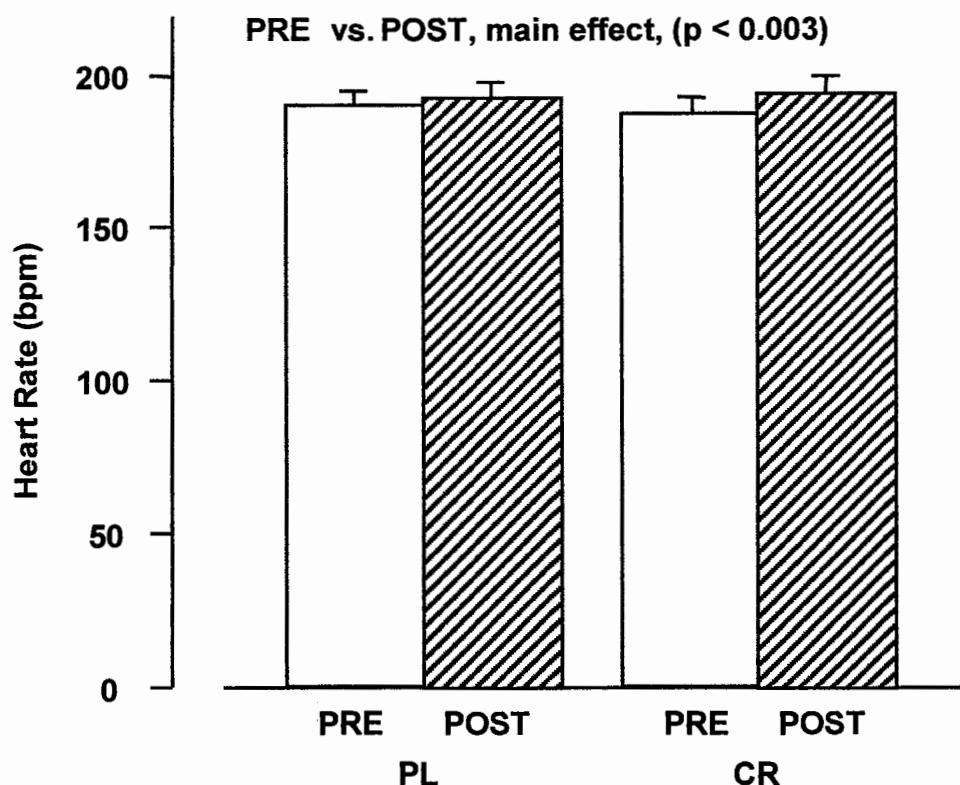


Figure 5. Peak heart rate during a graded maximal treadmill test before and after an 8-week, moderate cardiovascular program combined with 200 $\mu\text{g/day}$ chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Peak heart rate achieved was significantly greater after training (significant main effect; $p < 0.003$).

Body mass and anthropometrics

Body weight was not different between PL and CR before training or after eight weeks of a progressive resistance training program combined with two days of cardiovascular exercise. When data from PL and CR are combined, body mass did not change significantly due training (Figure 6).

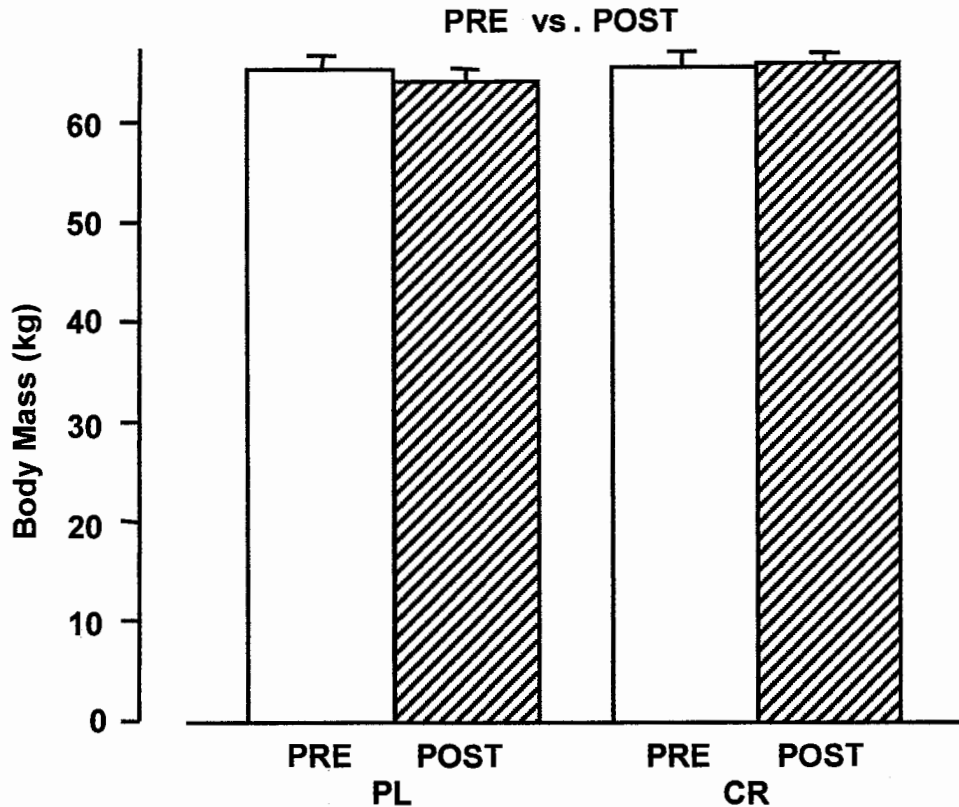


Figure 6. Body mass before and after an 8-week moderate cardiovascular program combined with a progressive resistance training program and 200 $\mu\text{g/day}$ chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. Body mass did not change in CR or PL.

Body Mass Index (weight (kg)/height (m^2)) was not different between PL and CR before training. However, following eight weeks of resistance training and cardiovascular exercise, BMI of CR increased significantly with training ($p = 0.02$) while BMI in PL decreased steadily with each increase in training intensity, perhaps reflecting the changes in body weight in each group.

The sum of seven skinfolds did not change due to training or supplementation. However, the interaction of training intensity with supplementation was significant ($p < 0.02$). The sum of seven skinfolds (Figure 7) decreased in PL (Pre = 128 mm \pm 11 vs. Post = 121 mm \pm 11) and increased in CR (Pre 122 mm \pm 11 vs. Post 128 mm \pm 11).

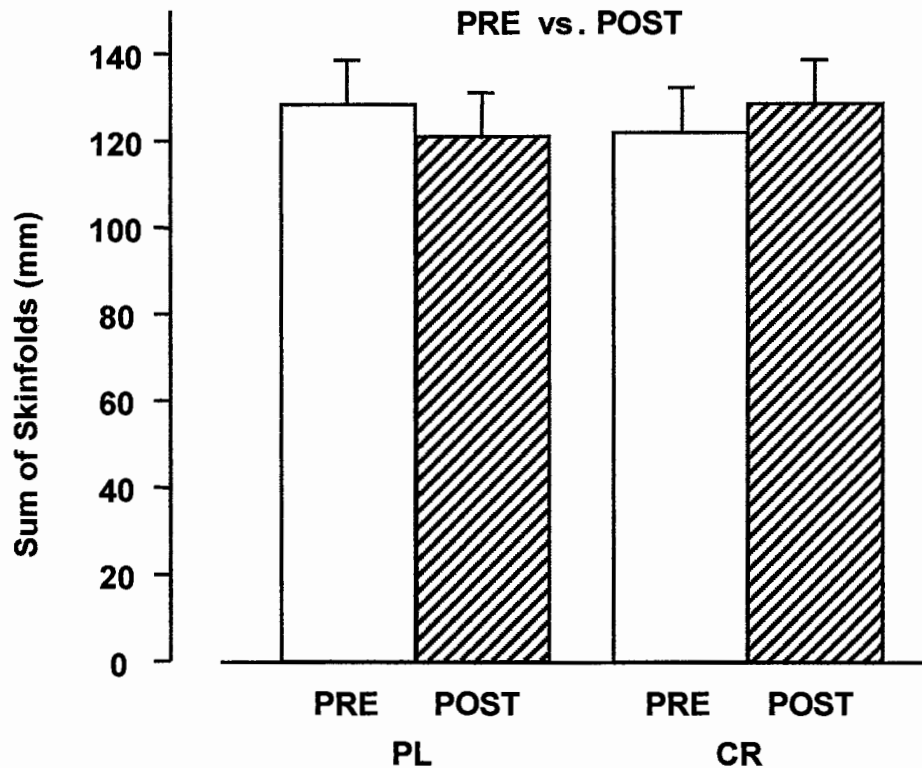


Figure 7. Sum of 7 skinfolds before and after an 8-week moderate cardiovascular program combined with a progressive resistance training program and 200 μ g/day chromium picolinate (CR, n=6) and placebo (PL, n=6) supplementation. Data are means \pm SE. Sum of skinfolds increased significantly after training in CR (significant main effect; $p < 0.02$) and decreased in PL.

The sum of eight girths did not change significantly due to group nor to the interaction of group with training. When data from PL and CR are combined, the sum of eight girths (Figure 8) decreased significantly due to training ($p < .003$) (Pre = $509.3 \text{ mm} \pm 5.6$ vs. Post = $500 \text{ mm} \pm 5.6$) involving both cardiovascular and resistance training exercise.

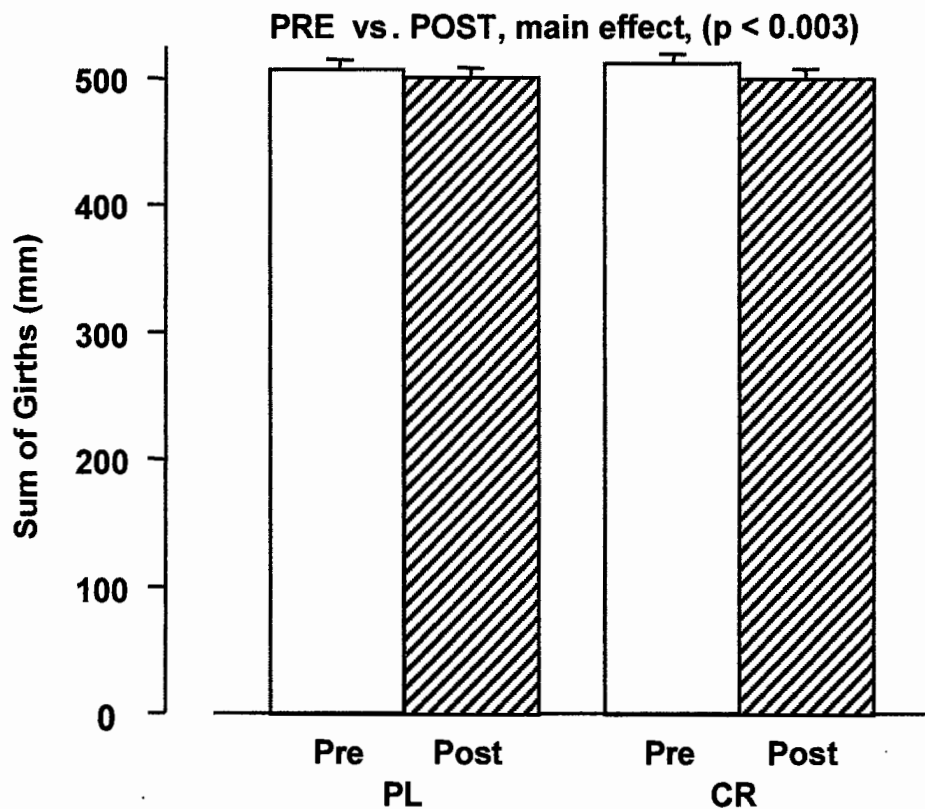


Figure 8. Sum of 8 girths before and after an 8-week moderate cardiovascular program combined with a progressive resistance training program and 200 $\mu\text{g/day}$ chromium picolinate (CR, $n=6$) and placebo (PL, $n=6$) supplementation. Data are means \pm SE. The sum of girths decreased significantly due to training alone (significant main effect; $p < .003$) in CR and PL.

CHAPTER V:

DISCUSSION

The purpose of this study was to examine the effects of chromium picolinate supplementation on changes in body weight and body composition when consumed in conjunction with a 'regular exercise program'. Chromium and chromium picolinate are marketed as weight loss enhancing supplements that increase lean body mass while decreasing body weight when taken in conjunction with a 'regular exercise program'. Although no specific exercise instructions are provided on product labels, the American College of Sports Medicine suggests that exercise intensities of at least 60% of a 1RM should be sufficient to increase strength. Additionally, the most rapid strength gains are achieved when a muscle is exercised at 80-100% of maximum exertion. To continue improving muscle strength with resistance training, resistance must be progressively increased to continue overloading the muscle. Furthermore, the ACSM recommends exercising at 70-85% of the heart rate achieved on symptom-limited treadmill test, for 20-60 minutes, 3-5 days per week. Thus, female subjects participated in progressive lower body resistance training and cardiovascular exercise program for eight weeks. One group consumed 200 µg of chromium picolinate daily throughout the 8-week training period while the other group received a placebo containing sucrose.

Both the cardiovascular and resistance training regimes had a training effect on both groups of subjects. However, the extent of the training was not related to chromium supplementation. The amount of weight lifted in a 1RM test on the leg press, knee extension and leg curl machines increased significantly due to the training but was not greater in the chromium supplemented group. Consequently, one may conclude that a training effect

occurred on the leg press machine in both PL and CR but was not enhanced by supplementation. However, training was not enhanced by supplementation. As described, these findings are consistent with previous research.

Chromium supplementation is thought to potentiate the action of insulin and thereby increase muscle mass by increasing amino acid uptake into cells to be incorporated into contractile proteins and elicit muscle cell hypertrophy. Thus, chromium would also be expected to enhance muscular strength. However, this was not the case in this investigation or in previous investigations. Hallmark et al., found that chromium supplementation taken in conjunction with a progressive, 12-week resistance training program did not enhance strength gains nor increases in lean body mass in males. Additionally, Hasten, et al. examined the effects of chromium picolinate on muscular strength, muscle girths, and skinfolds in both male and female subjects. Sum of girths increased and sum of skinfolds decreased in both groups. However, only the male subjects significantly increased strength. Furthermore, only female subjects increased body weight. It was concluded that chromium picolinate supplementation had a greater effect on females than on males but did not enhance training.

In the present study, the cardiovascular training also appeared to have been sufficient enough to elicit a cardiovascular training effect as demonstrated by the increased peak oxygen consumption and total exercise time in a graded exercise test post training. Although neither peak oxygen consumption nor exercise time was significantly different between groups, both factors increased significantly from pre to post training. Consequently, cardiovascular training was not enhanced with chromium supplementation either. Previous studies have demonstrated increased chromium losses following intense bouts of endurance exercise (7, 13, 70) and increased muscle tissue chromium levels in rats (70), but no

association has been made between chromium status and endurance performance in previous studies or in this investigation. Furthermore, no studies have included cardiovascular exercise in their training regime and analysis of body composition.

Although changes in body mass of PL and CR were not significant, it is interesting to note that not only did CR weigh less than PL pre training, CR subjects weighed more post training. However, chromium supplementation did not enhance weight loss or changes in body fat in this study. Furthermore, as previously noted, Hasten et al. observed increased bodyweight in only women subjects taking chromium with no significant change in the sum of skinfolds or muscle girths. Although one may speculate that the increased body weight in this study indicates an increase in lean body mass, no significant change in body composition was observed in either group.

In this investigation, body fat percentages decreased slightly in PL but not significantly. However, PL started with greater percent body fat than CR and ended with a lesser percent body fat than CR. Thus, the decreased weight in PL may be attributed to fat loss. Furthermore, CR started with lower percent body fat than PL yet ended with higher percent body fat than PL. The increased percent body fat of CR was statistically significant indicating that the weight gain was not due to increased lean tissue. Furthermore, when measuring changes in the specific muscles exercised, calf skinfold thickness was insignificant and unrelated to group, training, or the interaction of group with the training. Furthermore, the thigh skinfold thickness of CR was significantly greater post training reinforcing the suggestion that the increase in body mass was not due to an increase in lean body mass. In fact, thigh skinfold thickness of CR increased steadily with each increase in training intensity while thigh skinfold thickness remained relatively constant in PL. Although

no significant difference was found in thigh skinfold thickness due to neither group nor the interaction of group with training, the increased thigh skinfold thickness was observed in only CR.

In addition to the lower body skinfold sites, all individual skinfold sites were also examined. Abdominal skinfold measurements did not change significantly due to group or the interaction of group with training. However, the abdominal skinfold measurements of PL decreased to a greater extent than did CR. A significant difference in the abdominal skinfold from pre to post was found due to the training alone, aside from group, indicating that training alone did affect the size of abdominal skinfold measurement. Understanding the pattern of weight loss and gain in women, one may speculate that the decreased abdominal skinfold may account for the slight decrease in body fat observed in the sum of 7 skinfolds in PL. The pattern of weight loss/gain in women is understood to be that women lose weight in the following pattern: epigastric, lower gastric, gluteal, and femoral regions. Furthermore, it is the opposite pattern in regard to weight gain. Thus, although one would suspect that any changes in body composition would be reflected in the trained muscle groups, it may be that changes in the abdominal area also contributed even though no abdominal exercises were performed.

In addition to expecting lower body skinfold measurements to decrease due to training, lower body girths were expected to increase. Chromium is thought to increase muscle mass by increasing amino acid uptake into cells for incorporation into contractile protein and stimulate muscle cell hypertrophy. However, the sum of 8 girths did not change significantly due to group nor to the interaction of group with training. However, the sum of 8 girths decreased significantly due to training alone. Because the majority of girths taken

were from non-exercising muscles in the upper body, this finding demonstrates perhaps more the absence of upper body training rather than the presence of lower body training. In consideration of the two lower body girth measurements, no significant difference was found in the sum of the thigh and calf girths due to group, training, nor due to the interaction of group with training. Individual thigh and calf girths also did not change due to training, group, or the interaction of group with training. It is interesting that the sum of eight girths and the thigh and calf girth sums increased progressively through each training intensity up to the most intense training phase at which point girths decreased to the initial circumference. Although subjects were asked to continue training over spring break, exercise and food intake was not monitored for 10 days between training at 85% and 95% of the initial 1RM's. Additionally, perhaps motivation levels decreased at such a high intensity. Furthermore, because a training effect was observed during the first two training stages, the final training intensity perhaps should have been based on the most recent 1 RM rather than the initial 1RM. Although the exercises in this study targeted the femoral and gluteal regions, any change in physique may not manifest itself in these areas with such a short exercise program in women because of the pattern in which they tend to lose or gain weight. Thus, one may speculate that any measurable change in the lower body of female subjects would have to be accompanied by significant weight loss or a longer training period.

In conclusion, the findings of this investigation agree with that of Hallmark et al. and Clancy et al. in that chromium did not facilitate changes in strength during a moderate exercise program including progressive lower body resistance training in female subjects. Chromium is thought to increase muscle mass by increasing amino acid uptake into cells for incorporation into contractile protein and stimulate muscle cell hypertrophy. Thus, the

increase in lean tissue would be expected to increase muscle strength, increase muscle hypertrophy, decrease body fat, and decrease body weight. Additionally, one would expect a significant increase in thigh girth with an accompanying decrease in thigh skinfold due to the training alone. However, this was not the case in this study. Although these results demonstrate the efficacy of the training program, thigh and calf girths did not increase, body fat did not decrease, and body weight did not decrease. It is suspected that the lack of measured change be due to the length of the training program, the small number of subjects, and lack of adequate stimulus in the later stages of training.

APPENDIX A: TRAINING REGIMEN

Resistance Training			Cardiovascular Training		
<u>Week</u>	<u>Intensity</u>	<u>Sets/Repetitions</u>	<u>Frequency</u>	<u>Time</u>	<u>Frequency</u>
I, II	65% 1RM	3 x 12 repetitions	MWF	30 min.	T, Th
III-VI	85% 1RM	3 x 8-10 repetitions	MWF	30 min.	T, Th
VII, VIII	95% 1RM	5 x 3-5 repetitions	MF	30 min.	T, Th

Exercise session procedure:

Warm up 5 minutes performing light rhythmic, continuous movement

Perform the demonstrated stretches for the quadriceps, hamstrings, and gastrocnemius. Hold each position 10-30 seconds.

Resistance training:

Perform each repetition slowly allowing 4-7 seconds for the entire movement pattern, i.e. 2-3 seconds through the concentric phase, 3-4 seconds in the eccentric phase. Rest 1-2 minutes between each set. Record all repetitions

Cardiovascular training:

Perform 30 minutes of continuous cardiovascular exercise on either the treadmill or cycle ergometer at an intensity high enough to elicit a heart rate equal to 65-70% of your VO_{2peak} HR as indicated on the Exercise Record. Fifteen-second heart rates will be taken manually during the 15th minute of the exercise session and during the last minute of the exercise session.

Cool down for 5 minutes performing light, rhythmic, and continuous movement

Repeat static stretches

APPENDIX B: SAMPLE EXERCISE RECORD

Weeks I and II

Workouts 1-6

Name _____

Date _____

Time _____

Workout # _____

VO₂ peak _____HR_{max} _____70% VO₂peak _____

HR goal _____

Cardiovascular Exercise

Duration

15 minute HR

30 minute HR

Walking

Running

Stationary Cycling

Resistance Training

Exercise

Leg Press

Leg Curl

Knee Ext.

Initial 1RM:

Leg/Seat Adjustment:

Intensity: 65% 1RM=

Goal #Reps: 8-12

Set I

Set II

Set III

Leg Press

Leg Curl

Knee Extension

5 minute cool down & stretching

APPENDIX C: ANTHROPOMETRIC PROCEDURES

ACSM's Guidelines for Exercise Testing and Prescription. 1995.

Skinfold measurements

A fold of skin and subcutaneous fat is grasped with thumb and forefinger. The skin is pulled away from the underlying muscle, following the natural contours of the skin. The calipers are placed 1 cm away from the fingers, perpendicular to the skinfold and halfway between the base and crest of the skinfold. The measurement is read within two seconds (not longer) after the full force of the calipers has been applied. Pinch is maintained while reading caliper. The average of three measurements is recorded. If the three measurements are not within 1 to 2 millimeters of each other, retest. All measurements are taken on the right side of the body.

<i>Abdominal</i>	vertical fold 2 cm to the right of the umbilicus
<i>Triceps</i>	vertical fold on posterior midline of the upper arm, midway between acromion and olecranon processes
<i>Biceps</i>	vertical fold on anterior aspect of arm, over belly of muscle, 1 cm above level of triceps site
<i>Chest</i>	diagonal fold halfway between anterior axillary line and nipple (men) or one-third the distance between anterior axillary line and nipple (women)
<i>Medial calf</i>	vertical fold at maximum circumference on midline of medial border
<i>Midaxillary</i>	vertical fold on midaxillary line at level of xiphoid process
<i>Subscapular</i>	diagonal fold (45 degree angle) 1 to 2 cm below inferior angle of scapula
<i>Suprailiac</i>	diagonal fold in line with natural angle of iliac crest taken in the anterior axillary line immediately superior to the iliac crest

Thigh vertical fold on the anterior midline of the thigh midway between proximal border of patella and inguinal crease (at hip)

Circumference (girth) measurements

All limb measurements are taken on the right side of the body using a tension-regulated tape.

Subjects stand relaxed. Tape is placed perpendicular to the long axis of body part. Tape is pulled to the proper tension without pinching the skin. Duplicate measurements are taken.

Retest if measures are not within 7 mm (.25 inches).

Waist at narrowest part of torso (above umbilicus; below the xiphoid process)

Abdomen at the level of the umbilicus

Thigh legs slightly apart, at maximal circumference of the thigh (below the gluteal fold)

Arm arms at side, midway between the acromion and olecranon processes

Forearm arms slightly away from trunk, at the maximal forearm circumference

Wrist over ulnar styloid

Hip at maximal circumference around buttocks or hips (whichever is greater)

Calf at maximum calf circumference

APPENDIX D: BODY COMPOSITION CALCULATIONS

Seven-site formula

Sites measured: chest, midaxillary, triceps, subscapular, abdomen, suprailiac, thigh

Calculating Body Density for women:

$$\text{Body Density} = 1.0970 - 0.00046971(\Sigma 7 \text{ skinfolds}) + 0.00000056(\Sigma 7^2) - 0.00012828(\text{age})$$

Three-site formula

Sites measured: triceps, suprailiac, thigh

Calculating Body Density for women:

$$\text{Body Density} = 1.0994921 - 0.0009929(\Sigma 3) + 0.0000023(\Sigma 3^2) - 0.0001392(\text{age})$$

Calculating percent body fat

Seven-site formula

$$\text{Percent Body Fat} = 457/\text{Body Density} - 414.2 \quad \text{or} \quad 495/\text{Body Density} - 450$$

Three-site formula

$$\text{Percent Body Fat} = 457/\text{Body Density} - 414.2 \quad \text{or} \quad 495/\text{Body Density} - 450$$

APPENDIX E: SUBJECT SKINFOLD MEASUREMENTS**Group I: Placebo (PL)**

Skinfold

Site	Pre	Post 65%	Post 85%	Post 95%	SEM
Thigh	26.7	26.9	26.7	26.9	±2.31
Calf	17.1	17.0	16.3	17.3	±2.57
Abdominal	23.2	20.9	21.5	20.0	±2.83
Suprailiac	19.3	19.1	19.3	18.4	±2.22
Subscapular	17.9	18.1	19.0	17.3	±2.69
Midaxillary	13.3	14.3	12.5	12.0	±1.75
Chest	11.3	11.8	11.8	10.8	±1.42
Bicep	9.0	8.7	8.6	8.3	±1.01
Triceps	16.5	16.0	16.6	15.4	±1.36
$\Sigma 7$	128.2	127.0	127.5	120.7	±10.6

APPENDIX E CONTINUED: SUBJECT SKINFOLD MEASUREMENTS

Group II: Chromium (CR)

Skinfold

Site	Pre	Post 65%	Post 85%	Post 95%	SEM
Thigh	26.5	27.2	29.6	30.7	±2.31
Calf	21.6	20.2	20.3	20.6	±2.57
Abdominal	24.4	21.7	24.0	22.6	±2.83
Suprailiac	17.5	18.2	18.4	19.7	±2.22
Subscapular	16.3	15.7	17.5	17.1	±2.69
Midaxillary	12.6	12.7	13.1	12.8	±1.75
Chest	8.0	8.2	9.5	9.0	±1.42
Bicep	8.7	8.0	8.5	7.7	±1.01
Tricep	16.6	16.5	17.4	16.5	±1.36
Σ7	121.9	120.2	129.5	128.3	±10.6

APPENDIX F: SUBJECT GIRTH MEASUREMENTS**Group I: Placebo (PL)**

Girth

<u>Site</u>	<u>Pre</u>	<u>Post 65%</u>	<u>Post 85%</u>	<u>Post 95%</u>	<u>SEM</u>
Thigh	58.6	59.5	60.0	58.8	±1.16
Calf	36.7	36.8	37.3	36.7	±0.85
Hip	97.7	98.4	100.3	98.2	±1.86
Waist	72.5	73.4	73.3	72.0	±1.25
Abdomen	79.1	79.8	78.7	75.1	±2.19
Shoulder	103.3	103.6	103.6	101.7	±1.45
Upper Arm	27.0	26.9	26.8	26.3	±0.64
Neck	32.3	32.3	32.2	31.9	±0.59
Σ8	507.1	510.7	512.2	500.7	±7.84

APPENDIX F CONTINUED: SUBJECT GIRTH MEASUREMENTS

Group II: Chromium (CR)

Skinfold

Site	Pre	Post 65%	Post 85%	Post 95%	SEM
Thigh	59.6	60.4	60.1	60.1	±1.16
Calf	37.2	37.1	37.1	36.7	±0.95
Hip	99.5	101.7	100.6	99.4	±1.86
Waist	73.0	73.0	73.4	72.1	±1.25
Abdomen	78.9	80.1	79.4	75.8	±2.19
Shoulder	103.3	103.0	102.5	101.7	±1.45
Upper Arm	27.3	26.9	27.0	26.6	±0.64
Neck	32.6	32.3	32.2	32.0	±0.59
Σ8	511.5	514.6	512.4	499.1	±7.84

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